Patent claims

1. An integrated tunable RF resonator comprising an integrated inductor and a micromechanical tunable capacitor connected in series or in parallel, comprising
- a substrate,
- a first conducting layer for forming a first capacitor electrode,
- a second conducting layer for forming a second capacitor electrode,
- a third conducting layer for forming at least part of the inductor coil,
- a dielectric insulating layer between said first conducting layer and said third conducting layer, **characterised** in that the second capacitor electrode is movable relative to the first capacitor electrode, and the capacitor further comprises electrodes for applying a control voltage in order to create an electrostatic force to the movable first electrode for tuning the capacitance of the capacitor.

2. An integrated tunable RF resonator according to claim 1, **characterised** in that it comprises a substrate insulating layer between the substrate and the first conducting layer.

3. An integrated tunable RF resonator according to claim 1, **characterised** in that the first conducting layer forms an interconnecting wire between the inductor coil and the capacitor electrode.

4. An integrated tunable RF resonator according to claim 1, **characterised** in that, the second conducting layer and the third conducting layer is the same layer.

5. An integrated tunable RF resonator according to claim 1, **characterised** in that, some or all of the substrate is removed at the location of the first capacitor electrode of the capacitor structure.

6. An integrated tunable RF resonator according to claim 1, **characterised** in that, some or all of the substrate is removed at the location of the inductor coil.

7. An integrated tunable RF resonator according to claim 1, **characterised** in that, the substrate dielectric insulating layer is arranged as a suspending structure for the capacitor electrode and the inductor coil.

8. An integrated tunable RF resonator according to claim 1, **characterised** in that, the gap between the capacitor electrodes is an air gap.

9. An integrated tunable RF resonator according to claim 1, **characterised** in that the dielectric insulating layer is used as a sacrificial layer in creating the air gap.

10. An integrated tunable RF resonator according to Claim 1, **characterised** in that a thin insulating layer is deposited on top of the capacitor electrode to prevent the galvanic contact between electrodes.

11. An integrated tunable RF resonator according to Claim 10, **characterised** in that a thin insulating layer on top of the capacitor electrode covers the electrode only partly.

12. An integrated tunable RF resonator according to Claim 10, **characterised** in that a thin insulating layer on top of the capacitor electrode is silicon nitride.

13. An integrated tunable RF resonator according to Claim 10, **characterized** in that a thin insulating layer on top of the capacitor electrode is polymer.

14. An integrated tunable RF resonator according to claim 1, **characterised** in that the second capacitor electrode is the ground electrode.

15. An integrated tunable RF resonator according to claim 1, **characterised** in that the conducting layer interconnecting the inductor and the capacitor and/or the second capacitor electrode is metal film.

16. An integrated tunable RF resonator according to claim 1, **characterised** in that the first conducting layer comprises any of the following materials:
- refractory metal, such as Mo, W or TiW,
- metal, such as Au or Cu, or
- doped electrode in bulk silicon.

17. An integrated tunable RF resonator according to claim 1, **characterised** in that the second conducting layer comprises any of the following materials:
- metal, such as Au or Cu,
- polysilicon, or
- monocrystalline silicon.

18. An integrated tunable RF resonator according to claim 1, **characterised** in that the third conducting layer is metal, such as Au or Cu.

19. An integrated tunable RF resonator according to claim 19, **characterised** in that the third conducting layer is a electroplated layer with a substantially larger thickness than the thickness of the first and second conducting layers.

20. An integrated tunable RF resonator according to claim 1, **characterised** in that the inductor coil is arranged with the second conducting layer and an electroplated metal layer on top of the conducting layer.

21. An integrated tunable RF resonator according to claim 1, **characterised** in that the inductor coil is arranged to be adjustable.

22. An integrated tunable RF resonator according to claim 21, **characterised** in that the inductor coil has several segments, and it is arranged to be adjustable by means to change the number of active segments in the coil.

23. An integrated tunable RF resonator according to claim 22, **characterised** in that the segments of the inductor coil are changed by a micro-electro-mechanical switch realized in the same fabrication process with capacitors and inductors.

24. An integrated tunable RF resonator according to claim 1, **characterised** in that the inductor coil is a planar inductor coil.

25. A micromechanical tunable capacitor, comprising at least one counter electrode on a first plate of the capacitor, and at least one active electrode and at least one tuning electrode on a second capacitor plate, **characterised** in that,

- at least one of the capacitor plates is arranged to be a flexible and elastic structure,
- the active electrode is arranged to be positioned further from clamped points and/or sides than at least one tuning electrode.

26. A micromechanical tunable capacitor according to claim 25, **characterised** in that an RF-signal is arranged to be fed through the active electrode.

27. A micromechanical tunable capacitor according to claim 25, **characterised** in that a tuning signal is arranged to be fed through the tuning electrode.

28. A micromechanical tunable capacitor according to claim 25, **characterised** in that, the said electrode is metal thin film.

29. A micromechanical tunable capacitor according to claim 25, **characterised** in that the second capacitor electrode is folded and/or corrugated to at least two levels with respect to the first capacitor electrode.

30. A micromechanical tunable RF resonator according to claim 29, **characterised** in that the vertical portions of the folds and/or corrugates are fabricated thinner than the lateral portions of the second capacitor electrode.

31. A micromechanical tunable capacitor according to claim 25, **characterised** in that, the said arrangement is on a substrate.

32. A micromechanical tunable capacitor according to claim 31, **characterised** in that, the said substrate is glass, silicon, GaAs, or any other semiconductor material.

33. An integrated tunable RF resonator according to any of the claims 1-24, **characterised** in that said RF resonator comprises a micromechanical tunable capacitor according to claim 25.

34. A micromechanical tunable capacitor, comprising at least one counter electrode on one plate of the capacitor, and at least one active electrode and at least one tuning electrode on the other capacitor plate, **characterised** in that,

- the dielectric gap is arranged to be narrower between at least one active electrode and at least one counter electrode than between at least one tuning electrode and at least one counter electrode.

35. A micromechanical tunable capacitor according to claim 34, **characterised** in that an RF-signal is arranged to be fed through the active electrode.

36. A micromechanical tunable capacitor according to claim 34, **characterised** in that a tuning signal is arranged to be fed through the tuning electrode.

37. A micromechanical tunable capacitor according to claim 34, **characterised** in that, the said electrode is metal thin film.

38. A micromechanical tunable capacitor according to claim 34, **characterised** in that the second capacitor electrode is folded and/or corrugated to at least two levels with respect to the first capacitor electrode.

39. A micromechanical tunable RF resonator according to claim 38, **characterised** in that the vertical portions of the folds and/or corrugates are fabricated thinner than the lateral portions of the second capacitor electrode.

40. A micromechanical tunable capacitor according to claim 34, **characterised** in that, the said arrangement is on a substrate.

41. A micromechanical tunable capacitor according to claim 40, **characterised** in that, the said substrate is glass, silicon, GaAs, or any other semiconductor material.

42. An integrated tunable RF resonator according to any of the claims 1-24, **characterised** in that said RF resonator comprises a micromechanical tunable capacitor according to claim 34.

(57) Abstract

The invention relates to an arrangement for an integrated tunable resonator for radio and a method for producing the same. In particular the invention relates to an RF resonator realised with a micromechanical tunable capacitor with high Q- (quality factor) value and a method for fabricating the same. In one particular embodiment of the arrangement in accordance with the invention the first conducting layer (4) forms the first capacitor electrode (8), and/or the electrodes (9) to create the electrostatic force on the movable micromechanical structure (2), and the inter-connecting wire (10) between the inductor coil (1) and the capacitor electrode. The invention presents a substantial improvement to the linearity, power consumption, occupation space and reliability of RF resonator circuits.

Figure 6b